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TITLE OF THE INVENTION

Profiled Wing Unit of an Aircraft

PRIORITY CLAIM

This application is based on and claims the priority under 35 U.S.C. §119 of German Patent Application 103 46 982.6 filed on October 9, 2003, the entire disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

The invention relates to a profiled aircraft component that forms part of a wing unit or a tail unit. Such units have a leading edge and a trailing edge as well as an inner structure covered by a top skin and a bottom skin. Both skins are supported by the inner structure between the leading and trailing edges.

BACKGROUND INFORMATION

The control of a flying aircraft is accomplished by aerodynamically effective control surfaces such as ailerons, flaps, tabs, rudder surfaces and elevator surfaces referred to

herein as aircraft components or simply as control surfaces which are conventionally integrated into other aircraft components, e.g. wings and/or tail assemblies of an aircraft. Rolling motions of an aircraft are controlled by an aileron installed in each wing. Each aileron is normally connected to the respective wing trailing edge by a hinge that permits operating the aileron up or down for the intended influence on the flight situation.

Common to all control surfaces is the fact that these control surfaces have a relatively short length compared to the wing span of an aircraft while simultaneously having a large depth compared to the wing depth measured between the leading and trailing edge of the wing. As shown in Fig. 5 a control surface is normally connected to the wing by two hinges which provide a statically determined mounting. Due to the relatively small length of the control surface, such as an aileron, the difference between the deformation of the control surface, and the deformation or bending line of the wing also remains small. In such a mounting the bending of the wing in the z-direction is not imposed on the aileron, whereby no compulsion or unavoidable forces are generated in the aileron. Such forces would, however, occur for example in a mounting of the aileron to the landing flap with three hinges. Such unavoidable forces cause disadvantages which must be taken into account particularly where it is necessary to use slender control surfaces mounted with a continuous hinge connection formed by three or more hinges. In this connection the control surface under consideration has a length of about 4 m and a depth of about 0.4 m. Such a control surface technically

also referred to as "tab" must be connected with more than two hinges to the wing or to the landing flap as shown in Fig. 6 in order to assure an aerodynamically satisfactory connection, whereby the hinge lines coincide as shown in Fig. 6 when the control surface is not deflected.

The aerodynamically exact mounting shown in Fig. 6 is achieved only by the use of at least three hinges, whereby it is unavoidable that compulsion forces are imposed on the control surface by the bending of the component to which the control surface is hinged. In addition to the compulsion forces generated by the bending of the wing or landing flap to which the control surface is hinged, compulsion forces are also generated by the bending of the control surface itself about its stiff axis which has a large moment of inertia when the deflection takes place while the hinge line is bent.

Fig. 7 illustrates the formation of compulsion forces in the aileron or tab due to the bending of the component to which the tab is secured by a continuous hinge. The wing or landing flap is bent upwardly, whereby compulsion forces generate pressure in the tab when the tab is deflected upwardly, causing a negative tab deflection. When the tab is deflected downwardly, in a positive tab deflection, tension forces would be generated in the tab. Thus, depending on the bending direction of the component to which the tab is hinged, and depending on the positive or negative tab deflection, pressure or tension forces will be generated in the tab. Such forces can damage the tab to the

extent that it may fail unless countermeasures are taken. Such countermeasures call conventionally for either strengthening the stringers and/or ribs or installing additional stringers and/or ribs. In both instances additional weight cannot be avoided. Moreover, heavier tabs require higher actuator forces and larger mounting forces in the hinges must be taken up. Moreover, stiffer tabs may adversely influence the deformation characteristic and thus the aerodynamic characteristic of the component to which the tab is connected, for example a wing or a landing flap or tail unit.

OBJECTS OF THE INVENTION

In view of the foregoing it is the aim of the invention to achieve the following objects singly or in combination:

to construct an aircraft component and/or a control surface connected to such a component by at least three hinges in such a way that the above outlined problems are avoided;

to avoid or minimize the imposition of compulsion forces by making the respective component flexible in the y- and z-axis and stiff in the x-axis so that the respective component will adapt itself to the hinge line not only when the tab is in the 0° position, but also when it is deflected positively or negatively downwardly or upwardly;

to construct the respective component of lightweight materials such as CFC sandwich materials, to thereby reduce the weight of such components generally and specifically also at the areas where mounting forces must be taken up;

to achieve the above objects by aerodynamic improvements in the structure of the respective components and preferably also in components to which the present control surfaces are mounted;

to also minimize or avoid other adverse effects caused by the bending of a control surface and/or by the bending of the component to which the control surface is mounted; and

to reduce the mounting and actuator forces to achieve a weight reduction in the areas where these forces are normally effective, namely where these components are hinged to one another.

SUMMARY OF THE INVENTION

The above objects have been achieved according to the invention in a profiled aerodynamic aircraft component that comprises an inner structure such as spars and ribs between a leading edge and a trailing edge, whereby the component has a top skin and a bottom skin supported by the inner structure. The component has a longitudinal axis extending from end to end, in the x-direction, a depth axis extending between the leading and trailing edge in the y-direction. These components are equipped

according to the invention with at least one first ridge bulging outwardly in the top skin and at least one second ridge bulging in the bottom skin toward the at least one first ridge. The bulge extends in the z-direction. The first and second ridges are also referred to as first and second fins or rib fins. These ridges or fins begin in an area next to the trailing edge or preferably at the trailing edge and extend toward the leading edge in the direction of the depth axis and each rib or fin has a height that is largest in the trailing edge area and diminishes from the trailing edge area toward the leading edge.

The ridges or fins are provided in pairs so that the second ridge is at least partly nested in the first ridge to provide an improvement in the aerodynamic characteristic of the component equipped with such fins or ridges.

Where the component is equipped with several pairs of such ridges or fins, these pairs are spaced from one another along the longitudinal axis of the respective aircraft component, whereby the on-center spacing between neighboring ridges may be uniform and/or the spacings may differ from one another.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be clearly understood, it will now be described in connection with example embodiments thereof, with reference to the accompanying drawings, wherein:

Fig. 1 is a perspective, simplified illustration of an aircraft component such as a landing flap provided according to the invention with a pair of ridges or fins of which one fin is formed in the top skin and the other fin is formed in the bottom skin;

Fig. 2 shows a broken away perspective view of a first end of the two rib ridges which are joined to each other at least along a width in a trailing edge area;

Fig. 3 is a view similar to that of Fig. 2, however in the direction of the profile depth to illustrate the nesting of the two fins or ridges, one within the other to form a pair;

Fig. 4 shows a schematic view in the longitudinal direction of the component with the ridges forming a pair joined to each other in the hatched trailing edge area;

Fig. 5 shows a conventional two hinge mounting of a tab to a wing or landing flap;

Fig. 6 is a view similar to that of Fig. 5, but illustrating a three inch mounting;

Fig. 7 shows a two hinge mounting with the flap deflected in the negative, upward direction whereby the black

arrows show compulsion forces as pressure forces in the tab;

Fig. 8 illustrates schematically the primary object of the invention or rather aerodynamically desirable features that will minimize or avoid the imposition of compulsion forces on or in the tab; and

Fig. 9 illustrates a schematic top plan view of an aircraft wing or flap equipped with a tab provided with a plurality of ridges or fins.

DETAILED DESCRIPTION OF A PREFERRED EXAMPLE EMBODIMENT AND OF THE BEST MODE OF THE INVENTION

Figs. 5, 6 and 7 have been adequately described above and are self-explanatory with the labels provided in these prior art Figures.

Fig. 1 shows an aircraft component 12, for example a landing flap constructed according to the invention. The aircraft component 12 has an aerodynamic profile with an inner structure that includes a spar area 15 extending in the x-direction along the leading edge 1, a rib area not shown, and a trailing edge area 9 extending between a trailing edge 2 and a dashed line 11 which extends in the x-direction and parallel to the trailing edge 2. The dashed line 11 is spaced from the trailing edge 2 by a width

W to be described in more detail below. The trailing edge 2 is equipped with a trailing edge bar 16.

The profiled, aerodynamic component 12 has a top skin 4 and a bottom skin 5 mounted to the inner structure of the component. According to the invention a portion of the top skin 4 is formed outwardly in the z-direction to produce a first ridge or fin or rib fin 6. Similarly, a portion of the bottom skin 5 is deformed to form a second ridge, fin or rib fin 7 which nests at least partially inside the ridge or fin 6. The ridge 6 has a first ridge end 6A, preferably formed as a tip that is positioned on a fictitious line 10 extending in parallel to the leading edge 1 and spaced from the leading edge 1. This fictitious line 10 is preferably located in the spar area 15. The ridge 6 further has a first ridge portion 6B which has the above mentioned width W shown in Figs. 2, 3 and 4. The width W extends in the profile depth or y-direction. The first ridge portion 6B is connected to the first ridge end 6A by a ridge portion bounded by a ridge line 6C and top skin lines 6D and 6E. These lines 6C, 6D and 6E show how the first ridge 6 tapers from the trailing edge 2 toward the leading edge 1.

The ridge, fin or rib fin 7 is constructed and shaped in the same way as described above. Thus, the second ridge 7 has a second ridge end 7A and a second ridge portion 7B connected to the second ridge end 7A by the ridge line 7C and the bottom skin lines 7D and 7E. Thus, second ridge 7 also tapers from the second ridge portion 7B toward the second ridge end namely from

the trailing edge 2 toward the leading edge 1. Each deformed portion of the top skin 4 and of the bottom skin 5 is shaped or formed or molded in the z-direction in such a way that the ridge or rib 7 is at least partially nested within the ridge 6, thus forming a pair of ridges 6 and 7. Preferably, the first ridge end 6A and the second ridge end 7A are located vertically one above the other on a common vertical line L1 extending in the z-direction.

Incidentally, the component 12 has a profile centerline 8 extending in the y-direction and a profile depth t from leading edge 1 to trailing edge 2 in the y-direction.

Referring to Figs. 1, 2, 3 and 4 in conjunction, the first end portion 6B of the ridge 6 and the second end portion 7B of the second ridge 7 are so shaped that the surfaces of the first and second end portions 6B and 7B are in intimate contact with each other along the width W in the y-direction in the trailing edge area 9 where the two ridges 6 and 7 forming a pair are permanently bonded to each other. This bond may be made with the help of a cold or hot adhesive which may be either a single component or a multi-component adhesive or any other suitable adhesive, whereby the bonding may be enhanced by heating and/or pressing for a respective curing when the top skin 4 and the bottom skin 5 are made of fiber composite materials such as CFCs. The two ridge surfaces forming the end portions 6B and 7B may be riveted to one another in the area with the width W, particularly if the top and bottom skins are made of materials suitable for

riveting. In all of these embodiments the ridge or ridges stiffen the respective top or bottom skin 4, 5 particularly in the z-direction while simultaneously making the component provided with the ridges flexible around the z-axis and the y-axis as shown in Fig. 8. The flexibility about the z-axis avoids or minimizes the introduction of compulsion forces into the component such as a tab even if the tab is deflected out of its 0°-position. Similarly, the flexibility about the y-axis of the tab permits an aerodynamic conformity of the tab to the component such as a flap. However, the tab remains stiff in the x-direction and there is no aerodynamic deformation in the x-direction when the tab is deflected. Please see Fig. 8.

Figs. 2 and 3 show the adhesive bonding AB merely as an interface between the ridges 6 and 7. Fig. 2 further shows a ± 45° fiber orientation in the fiber composite materials of which the top skin 4 and the bottom skin 5 are made. The ridges 6 and 7 have a height H, whereby the height of the outer or upper ridge 6 is smaller than the height of the lower or inner ridge 7. A complete bonding is assured between the interface surfaces of the two ridges 6 and 7 along the width W corresponding to the width of the trailing edge area 9 which is reinforced by the above mentioned trailing edge bar 16 as seen in Figs. 1 and 4. The first end 6B of the first ridge 6 and the second end 7B of the second edge 7 as shown in Fig. 3 do not need to coincide with their end face exactly with the trailing edge 2. It is satisfactory if the ridges 6 and 7 start within the width W. In any construction the ridge lines 6C and 7C will be spaced from

each other between the bonded area and the respective ridge end 6A, 7A. The respective spacing VS is shown in Figs. 1 and 4 and increases from right to left due to the tapering of the ridges 6 and 7 from right to left in Fig. 4. Correspondingly, the height H of the respective ridge 6 and 7 diminishes from right to left. This construction provides the required flexibility around the z-axis while permitting a stiffening of the skins 4 and 5 in the z-direction. Particularly, the bonding of the ridges 6 and 7 to each other along the width W strengthens the entire tab structure in the x-direction, whereby the ridges take over the function of the ribs in a profiled aircraft component. The height H of the ridges 6 and 7 can be diminished from right to left in Fig. 4 because their neutral phase runs along the respective ridge lines 6C and 7C where the least deformations take place when the respective component is operated to deflect up or down. These ribs according to the invention stiffen the entire structure in the x-direction, thereby improving the capability of the structure to transmit or take up shearing forces. Due to the bonding of the ridges to each other along the width W no seal of the stretchable zone at the end of the ridges 6, 7 is required. In a component according to the invention the box spar 15 takes up any torsion loads and is thus dimensioned to be sufficiently stiff for this purpose, whereby a spar 15 with a closed cross-sectional profile having a $\pm 45°$ fiber orientation in the fiber composite construction of the spar 15 is ideal. Fig. 4 shows such a closed profile of the spar 15.

Fig. 9 shows an aircraft component 12A such as a wing or a landing flap or a tail fin. A tab 18 constructed according to the invention, for example as a CFC fintab is secured with its leading edge to the trailing edge of the component 12A by a plurality of hinges 17. A plurality of ridges 6 and 7 forming respective pairs of ridges as described above is spaced at predetermined spacings along the tab 18. These predetermined on-center spacings between neighboring pairs of ridges 6, 7 may be uniform or may differ from one another. Flap track fairings 19, 20 which house actuators 21 and 22 for deflecting the tab 18. The fairings 19, 20 are mounted on the component 12A. Each faring is equipped with cut-outs to accommodate the deflection motion of the tab 18. Each actuator 21, 22 is constructed to provide about 50% of the required power for operating the tab 18 which is preferably made of carbon fiber composite materials, CFC-fin tip.

The length L of the ridges 6, 7 is either shorter or longer than one half of the profile depths t, depending on the desired aerodynamic characteristics of the component. Preferably the ridges are longer than the profile depth t and end at 6A, 7A in the spar area 15. The ridge ends 6A, 7A are preferably, but not necessarily aligned along a line L1 extending perpendicularly to the depth axis 8. Regardless of the position of the ridge ends 6A, 7A, these ridge ends 6A, 7A are preferably shaped as pointed tips to provide a desirable aerodynamic ridge configuration, particularly for the first ridge 6 in the top skin 4.

The bulging-out configuration of the ridges 6, 7 as best seen in Fig. 3 has preferably but not necessarily a sectional configuration that resembles a parabola which opens downwardly in a wing component such as a flap, tab or aileron, or it opens backwardly in a tail component such as a rudder fin or tab. In an elevator component the ridge sectional configurations also opens downwardly.

The ridges 6, 7 preferably have the outer configuration of a longitudinal portion of an aerodynamically formed cone that is cut-off lengthwise, but not necessarily along a central longitudinal cone axis.

Although the invention has been described with reference to specific example embodiments, it will be appreciated that it is intended to cover all modifications and equivalents within the scope of the appended claims. It should also be understood that the present disclosure includes all possible combinations of any individual features recited in any of the appended claims.